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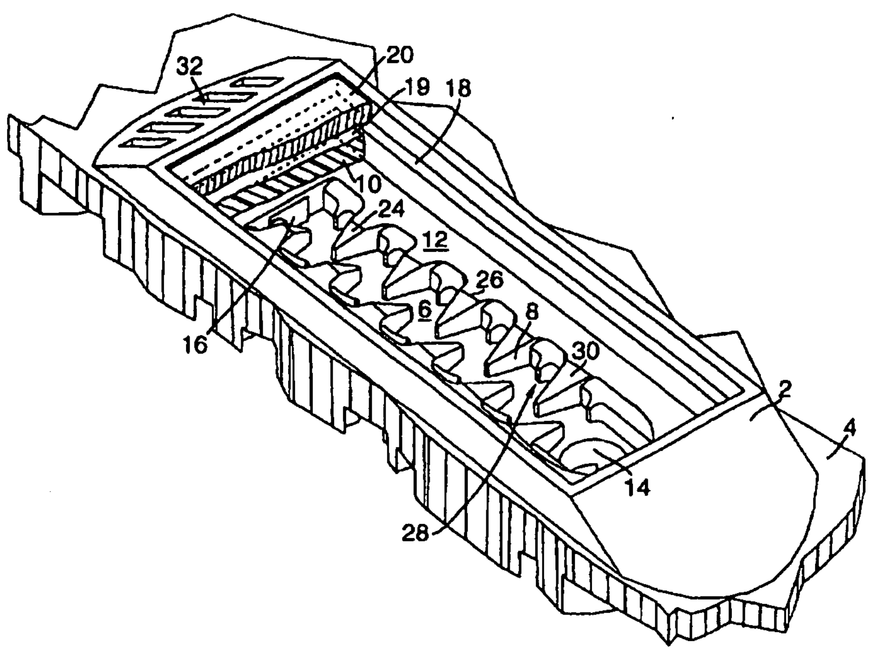
(54) Title: A FLOW-REGULATING ELEMENT AND DRIP IRRIGATION UNITS UTILIZING SAME

(57) Abstract




An arrangement (4) for a drip irrigation emitter, including a flow-regulating element consisting of a body (2) attachable to or integral with the emitter arrangement (4), in which body (2) there is provided a set of meandering, interconnected recesses defining in conjunction with an elastically deformable diaphragm (10) a flow-regulating labyrinth (6) having inlet and outlet means (14, 16), recesses in the body being defined by toothlike baffles (8) projecting in a staggered arrangement from two opposite walls of the labyrinth (6), which baffles (8) have a top surface defining a position of rest of the elastically deformable diaphragm (10), each of the toothlike baffles (8) ending in a relatively narrow edge, wherein the edge extends from the bottom of the recesses to a point at a height lower then the height of the top surface (12), at least one surface extending from each of the points towards the top surface (12), and intersecting therewith, above which at least one surface the diaphragm (10), in its position of rest, is freely suspended, and wherein, during operation of the emitter, flow regulation is at any instant carried out along the entire usable length of the flow-regulating labyrinth (6).

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# A FLOW REGULATING ELEMENT AND DRIP IRRIGATION UNITS UTILIZING SAME

## Technical Field

The present invention relates to a flow-regulating element for use in drip irrigation emitters. The invention also relates to drip irrigation emitters using such elements.

## Background Art

Drip irrigation has by now become a universally accepted concept, the advantages of which are well understood and need no further explanation. Drip irrigation emitters, on the other hand, while operating on basically similar principles, are still being improved and refined.

Apart from being inexpensive and having a reasonable service life, emitters must meet two basic conditions: their output must be constant and uniform in spite of substantial pressure fluctuations in the supply line and, in spite of the sometimes very low outputs required, they must have passageways for the irrigation water that are large enough to prevent clogging by particulates that, under field conditions, are inevitably present in the water.

In present-day emitters, efforts have been made to resolve the apparent contradiction between high line pressure, low outputs, yet relatively large passageways by providing a labyrinth covered by a diaphragm exposed to line pressure that senses the difference between line pressure and the pressure in the labyrinth which, at the output end thereof, obviously equals atmospheric pressure. This difference, if large enough, causes the diaphragm to bulge into portions of the labyrinth, reducing the free cross-section of the latter and, thus, the emitter output. Reduced output, however, will reduce the pressure differential across the diaphragm, enabling the elastic resilience of the diaphragm to "unbulge," thus again increasing output to the point where the differential is again large enough to elastically deform the diaphragm.

U.S. Patent 5,400,973 teaches an emitter based on the above-explained principle, with the labyrinth defined by baffles and with the clearance between the baffles and the baffle-facing surface of the diaphragm gradually increasing in the

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direction of flow. Due to this particular design, the diaphragm will make contact with the baffles only sequentially. As a labyrinth becomes effective only where fully covered by the diaphragm, it is clear that over a significant range of pressures only a relatively short length of the labyrinth is effective, the pressure-drop producing effect of the uncovered baffles being insignificant. The serious drawback of this design resides in the fact that, to enable the short length of the actually effective labyrinth to produce the required pressure drop, the passageway has to be narrowed down, thereby significantly increasing the danger of clogging.

**Disclosure of the Invention**

It is thus one of the objects of the present invention to provide a flow-regulating element that produces a substantially constant and uniform output over a wide range of line pressures, while having a labyrinth with a passageway of a cross-section large enough to greatly reduce the risk of clogging.

According to the invention, the above object is achieved by providing, in combination with a drip irrigation emitter, an arrangement comprising a flow-regulating element consisting of a body attachable to or integral with said emitter arrangement, in which body there is provided a set of meandering, interconnected recesses defining in conjunction with an elastically deformable diaphragm a flow-regulating labyrinth having inlet and outlet means, said recesses in said body being defined by toothlike baffles projecting in a staggered arrangement from two opposite walls of said labyrinth, which baffles have a top surface defining a position of rest of said elastically deformable diaphragm, each of said toothlike baffles ending in a relatively narrow edge, wherein said edge extends from the bottom of said recesses to a point at a height lower than the height of said top surface, at least one surface extending from each of said points towards said top surface and intersecting therewith, above which at least one surface said diaphragm, in its position of rest, is freely suspended, and wherein, during operation of said emitter, flow regulation is at any instant carried out along the entire usable length of said flow-regulating labyrinth.

The invention further provides a line-pressure independent, regulated-flow, in-line drip irrigation emitter, comprising a substantially tubular emitter housing having a substantially cylindrical outer surface and being insertable into an irrigation line,

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with said outer surface tightly fitting the inner surface of said irrigation line; an elongated body located inside, and integral with, said emitter housing; a first set of meandering, interconnected recesses extending over a portion of said outer cylindrical surface and defining, in conjunction with said inner surface of said irrigation line, a flow-attenuating labyrinth, a first end of said flow-attenuating labyrinth communicating with said irrigation line, the second end thereof communicating via an aperture with a first end of a second set of meandering, interconnected recesses provided in said body and defining, in conjunction with an elastically deformable diaphragm, a flow-regulating labyrinth, the second end of which labyrinth communicates through a duct with the free atmosphere via at least one peripheral channel in said cylindrical body and via at least one hole in said irrigation line, said recesses in said flow-regulating labyrinth being defined by toothlike baffles projecting in a staggered arrangement from two opposite walls of said labyrinth, which toothlike baffles have a common top surface defining a position of rest of said elastically deformable diaphragm, each of said baffles ending in a relatively narrow edge; wherein said edge extends from the bottom of said recesses to a point at a height lower than the height of said top surface, at least one surface extending from each of said points towards said top surface and intersecting therewith, above which at least one surface said diaphragm, in its position of rest, is freely suspended and wherein, during operation of said emitter, flow regulation is at any instant carried out along the entire usable length of said flow-regulating labyrinth.

The invention still further provides a boat-type, regulated-flow, in-line drip irrigation emitter, comprising an elongated body attachable to the inside wall of an irrigation water supply line; a first set of meandering, interconnected recesses extending over a portion of the outside surface of said body and defining, in conjunction with said inside wall, a flow-attenuating labyrinth, a first end of said flow-attenuating labyrinth communicating with said supply line and a second end thereof communicating via an aperture with a first end of a second set of meandering, interconnected recesses located in said body and defining, in conjunction with an elastically deformable diaphragm, a flow-regulating labyrinth, the second end of which labyrinth communicates with the free atmosphere via a pool-like depression in

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said body and via at least one hole in said line, said recesses in said flow-regulating labyrinth being defined by toothlike baffles projecting in a staggered arrangement from two opposite walls of said labyrinth, which toothlike baffles have a common top surface defining a position of rest of said elastically deformable diaphragm, each of said baffles tapering down towards a relatively narrow edge; wherein said edge extends from the bottom of said recesses to a point at a height lower than the height of said top surface, at least one surface extending from each of said points towards said top surface and intersecting therewith, above which at least one surface said diaphragm, in its position of rest, is freely suspended and wherein, during operation of said emitter, flow regulation is at any instant carried out along the entire usable length of said flow-regulating labyrinth.

The invention yet further provides a button-type, regulated-flow drip irrigation emitter, comprising a two-part housing, a first part of which is provided with inlet means connectable to an irrigation line, and a second part of which is provided with outlet means, said first and second parts being joinable by joining means; a disk-shaped, elastically deformable diaphragm disposed between said first and said second housing parts, and having a substantially central opening communicating in the mounted position of said diaphragm with said inlet means; a first set of meandering, interconnected recesses extending over a portion of an inside surface of said second housing part and defining, in conjunction with said diaphragm, a flow-attenuating labyrinth, a first end of which communicates via said opening in said diaphragm with said irrigation line, the second end thereof being connected to the first end of a second set of meandering, interconnected recesses provided in said surface of said second housing part and defining, in conjunction with said diaphragm, a flow-regulating labyrinth, the second end of which communicates with said outlet means, said recesses in said flow-regulating labyrinth being defined by toothlike baffles projecting in a staggered arrangement from two opposite walls of said labyrinth, which toothlike baffles have a common top surface defining a position of rest of said elastically deformable diaphragm, each of said baffles ending in a relatively narrow edge; wherein said edge extends from the bottom of said recesses to a point at a height lower than the height of said top surface, at least one surface extending from

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each of said points towards said top surface and intersecting therewith, above which at least one surface said diaphragm, in its position of rest, is freely suspended and wherein, during operation of said emitter, flow regulation is at any instant carried out along the entire usable length of said flow-regulating labyrinth.

The invention will now be described in connection with certain preferred embodiments with reference to the following illustrative figures so that it may be more fully understood.

With specific reference now to the figures in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

In the drawings:

Fig. 1 is a perspective view of a first embodiment of the flow-regulating element according to the invention;

Fig. 2 is a view, greatly enlarged, of a part of the flow-regulating element of Fig. 1;

Fig. 3 shows the flow-regulating element as an integral part of a cylindrical drip irrigation emitter represented in cross-section;

Fig. 4 is a perspective view of a first embodiment of a drip irrigation emitter arrangement incorporating the element according to Fig. 1;

Fig. 5 illustrates the arrangement of Fig. 4 rotated by about 180°;

Fig. 6 is a view in cross-section along planes VI-VI in Fig. 3;

Fig. 7 shows a section of the supply line with the cylindrical drip irrigation arrangement inserted;

Figs. 8 to 10 are schematic cross-sections of the regulating labyrinth at the upstream end thereof;

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Figs. 11 to 13 are schematic cross-sections of the regulating labyrinth at the downstream end thereof;

Fig. 14 represents a flow-regulating element for a diaphragm of a thickness that changes along its longitudinal extent;

Fig. 15 illustrates a longitudinal cross-section showing such a diaphragm as seated in the flow-regulating element of Fig. 14;

Fig. 16 is a cross-sectional view of a boat-type emitter as attached to the interior of a supply line;

Fig. 17 shows the flow-regulating labyrinth inside the emitter;

Fig. 18 is a longitudinal cross-sectional view of the emitter of Fig. 17;

Fig. 19 shows the flow-attenuating labyrinth of the emitter;

Fig. 20 is an exploded view of a button-type emitter according to the invention, and

Fig. 21 is a bottom view of the upper housing portion of the emitter of Fig. 20.

**Detailed Description of Preferred Embodiments**

Referring now to the drawings, there is seen in Fig. 1 a body 2 of the flow-regulating element according to the invention which, in this embodiment, is an integral part of a cylindrical drip irrigation arrangement 4, seen to better advantage in Fig. 3. There is also seen a meandering flow path or labyrinth 6 constituted by interconnected recesses mainly defined by toothlike baffles 8 which, in a staggered arrangement, project from two opposite walls of body 2. In conjunction with an elastically deformable diaphragm 10 resting on a common top surface 12 of baffles 8, the latter define a flow-regulating labyrinth having an inlet aperture 14 and an outlet aperture 16, by means of which the regulating element is connected to other parts of the arrangement, as will be explained further below.

Above the upper surface of diaphragm 10, body 2 is provided with a shoulder 18 on which is supported a cover lid 20 which prevents the loosely seated diaphragm10 from accidentally dropping off surface 12. Lid 20 is also provided with openings (not shown) through which full line pressure has access to upper surface 19 of diaphragm 10.

The particular shape of toothlike baffles 8 is shown to better advantage in Fig. 2, where it is seen that each of baffles 8 ends in a relatively narrow edge 22, the

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height $h$ of which is the same for all baffles 8 and is less than the height $H$ of top surface 12 above the bottom of labyrinth 6. It is seen that inclined surfaces 24 extend from the upper ends of edges 22, to interconnect with top surface 12. It is also seen that the angle of inclination $\alpha$ of surfaces 24 varies, with $\alpha_1$, the angle of baffle 8 closest to inlet aperture 14 being smaller than $\alpha_6$, the angle of baffle 8 closest to outlet opening 16.

It is also obvious that diaphragm 10 is supported by top surface 12 only up to the lines of intersection 26 between top surface 12 and inclined surfaces 24, and is freely suspended above these surfaces 24, with the freely suspended portions of diaphragm 10 varying in extent as a function of angle $\alpha$, being at a maximum with $\alpha_1$ (adjacent to inlet aperture 14) and at a minimum with $\alpha_6$ (adjacent to outlet aperture 16). The significance of this feature will become apparent further below.

While in the present embodiment surfaces 24 are substantially planar, they could also be curved either concavely or convexly, or could be twisted, or could consist of more than one surface including various angles with each other. Also, the lines of intersection 26 may be imaginary or virtual, as will be the case if the edges formed by these lines are broken or rounded.

It is seen that imaginary, straight lines can be drawn through lines of intersection 26 (Figs. 1, 2) on both sides of labyrinth 6. Such straight lines will converge from the upstream end of labyrinth 6 towards its downstream end, the lines including an angle of up to approximately 6°.

The flow-regulating element according to the invention is also provided with a set of minor baffles 28, each minor baffle 28 being positioned in the space between two toothlike baffles 8. Minor baffles 28 have slanting top surfaces 30 with, however, identical angles of shape.

Fig. 3 shows the position of the flow-regulating labyrinth 6 inside the cylindrical drip irrigation arrangement. Also seen is a first strainer 32 which the irrigation water must pass to eventually enter the flow-regulating labyrinth 6. Diaphragm 10 and lid 20 are not shown.

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A perspective view of the cylindrical drip irrigation arrangement incorporating the flow-regulating element according to the invention is seen in Fig. 4 and shows one side of the substantially cylindrical drip irrigation arrangement. There is seen the substantially cylindrical housing 4 made of a moldable plastic material and fitting the extruded supply line 34 seen in Fig. 7. Housing 4 is provided with two peripheral channels 36 into which, in a manner to be explained further below, flows the flow-regulated water and from which it reaches the atmosphere via holes 38 located over channels 36 and/or 36' (Figs. 5, 7).

Also seen is a flow-attenuating labyrinth 40 defined by meandering grooves 42 when enclosed by line 34 (Fig. 7). Labyrinth 40 has an inlet opening 44 fed from a strainer 46 which is, in fact, the underside of first strainer 32, while outlet opening 48 is, in fact, identical with inlet opening 14 of Figs. 1 and 2. It will be appreciated that in the position of housing 4 shown in Fig. 4, flow-regulating labyrinth 6 which, as will be remembered, is integral with housing 4, is now located upside down below flow-attenuating labyrinth 40. Its outlet aperture 16 (Fig. 1) continues, shaft-like, into a peripheral groove 50 whence, via recess 50 and past ribs 54, flow-regulated water reaches peripheral channels 36, 36' and, through holes 38 (Fig. 7) reaches the atmosphere. Housing 4 ends in flanges 56 with sealing grooves 58.

It should be remembered that labyrinth 40 merely has a flow-attenuating function, i.e., it serves as a preliminary pressure-reducing stage.

In Fig. 5, the arrangement of Fig. 4 has been rotated about its axis by approximately 180°. There is seen a large, window-like opening 60 required for purely technological purposes (stripping of the molding core forming flow-regulating labyrinth 6) and an additional strainer 62 communicating with the interior of line 34 which, via a groove 64, provides an additional supply of strained water to labyrinth 40. Through window 60 can be seen flow-regulating labyrinth 6 (without diaphragm 10 and cover lid 20), as well as inlet aperture 14.

Fig. 6 clearly represents the relative positions of flow-regulating labyrinth 6 with its toothlike baffles 8 and minor baffles 28, and the flow-attenuating labyrinth 40.

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The working principle of the flow-regulating element is *per se* known and has been briefly touched upon in the foregoing. The characterizing feature of the present flow-regulating element resides in the fact that, in contradistinction to prior art regulators, the most relevant of which has been discussed in the introductory part of the specification, flow regulation is at any instant carried out along the entire usable length of flow-regulating labyrinth 6, greatly enhancing sensitivity to changes in line pressure as well as self-cleaning capability.

It will be appreciated that pressure differentials are largest at the downstream end of regulating labyrinth 6, and smallest at the upstream end thereof. In recognition of this fact, provision has been made at the upstream end of labyrinth 6 for diaphragm 10 to bulge, and thereby reduce the free cross-section of labyrinth 6, at relatively small pressure differentials, while taking care that, at the downstream end, larger pressure differentials will be needed to bulge diaphragm 10.

Figs. 8-10 are schematic cross-sections of regulating labyrinth 6 at the upstream end thereof, i.e., adjacent to inlet aperture 14, where the angle of inclination $\alpha_1$ of surface 24 is the smallest and the freely suspended portion of diaphragm 10 the largest. Also seen is minor baffle 28 with its sloping surface 30.

Fig. 8 shows diaphragm 10 at rest, i.e., under zero differential pressure, being freely suspended over the relatively long surface 24.

Fig. 9 represents the situation at a relatively moderate pressure differential. Diaphragm 10 is seen to slightly bulge into labyrinth 6, but the bulging force is balanced by the elastic resilience of diaphragm 10.

In Fig. 10, differential pressure has increased to the point where the lower surface of diaphragm 10 is in full contact with surfaces 24 and 30. Due to the now greatly reduced free cross-section, and thus reduced throughput, of labyrinth 6, the differential pressure will drop and, in the next stage of the regulation cycle, diaphragm 10 will reduce the extent of its bulging.

Figs. 11-13 depict the analogous situation at the downstream end of labyrinth 6, i.e., adjacent to outlet aperture 16, where the inclination $\alpha_6$ of surface 24 is much

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steeper. The effects of zero, moderate and high pressure differentials are analogous, too.

The effect of distributing the regulating work over the entire labyrinth and diaphragm can also be achieved by means other than varying the angles of inclination of surfaces 24 between $\alpha_1$ and $\alpha_6$, namely, by making all angles $\alpha$ equal, but using a diaphragm 10′ that changes its thickness along labyrinth 6, from a maximum at the downstream end (adjacent to outlet aperture 16), to a minimum at the upstream end (adjacent to inlet aperture 14).

Such a solution is seen in Figs. 14, 15. the toothlike baffles in Fig. 14 are seen to be identical, with identical angles of slope (indicated by the fact that lines of intersection 26 are non-converging, i.e., parallel). Fig. 15 shows diaphragm 10′, which is seen to be thickest at the downstream end, and thinnest at the upstream end.

The effect of the varying sizes of freely suspended diaphragm portions combined with a uniform thickness (uniform moment of inertia) of the diaphragm is basically the same as that of a uniform size of freely suspended diaphragm portions combined with a varying thickness (varying moment of inertia) of the diaphragm.

Nevertheless, the possibility is also envisaged of combining the effect of the varying-slope baffles (e.g., Fig. 1) with the effect of the varying-thickness diaphragm (Fig. 15).

Figs. 16-20 represent another embodiment of the invention, a boat-type drip irrigation arrangement incorporating the flow-regulating element according to the invention.

Fig. 16 shows the boat-type drip irrigation arrangement including supply line 34, to which the flow-regulating element is attached during the extrusion process of line 34. Diaphragm 10 and cover lid 20 are seen to be held by means of four pins 66.

Figs. 17 and 18 show flow-regulating labyrinth 6, including inlet aperture 14 and outlet aperture 16, and strainer 32, as well as a pool 68 into which the water flows after passing labyrinth 6. Emitter holes 38 (not shown) punched into line 34 are so located as to register with pool 68.

Express Label No.
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Fig. 19 shows the flow-attenuating labyrinth 40, its outlet opening 48 (which coincides with inlet aperture 14 of flow-regulating labyrinth 6) as well as the extent of pool 68.

Fig. 20 is an exploded view of a button-type drip irrigation emitter incorporating the flow-regulation element according to the invention. There is seen a two-part housing 70, 72 joined by thread means 74, 74′ and holding between them a disk-shaped diaphragm 10 with a central hole 76, through which water can enter via the barbed stem 78 of housing part 70, forced into a hole punched into line 34 (not shown).

Fig. 21 is a view of housing part 72 as seen in the direction of arrow *A*. Water coming through stem bore 79 enters flow-attenuating labyrinth 40 which, in this embodiment, is co-planar with, and directly connected to, flow-regulating labyrinth 6, the outlet aperture 16 of which leads into a connector 80 for rubber tubing or the like. Line pressure acts on the underside of diaphragm 10 via an annular groove 82 that communicates with stem bore 79 via a radial groove 84. The regulating principle is the same as with the regulating elements of the other embodiments.

It should be noted that, while in the embodiments described diaphragm 10, 10′ is freely accommodated in the space above top surface 12 (e.g., Fig. 1), similar flow-regulating effects could also be obtained by clamping a peripheral portion of diaphragm 10, 10′ against top surface 12.

It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrated embodiments and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

## CLAIMS

1. In combination with a drip irrigation emitter, an arrangement comprising:

a flow-regulating element consisting of a body attachable to or integral with said emitter arrangement, in which body there is provided a set of meandering, interconnected recesses defining in conjunction with an elastically deformable diaphragm a flow-regulating labyrinth having inlet and outlet means, said recesses in said body being defined by toothlike baffles projecting in a staggered arrangement from two opposite walls of said labyrinth, which baffles have a top surface defining a position of rest of said elastically deformable diaphragm, each of said toothlike baffles ending in a relatively narrow edge,

wherein said edge extends from the bottom of said recesses to a point at a height lower than the height of said top surface, at least one surface extending from each of said points towards said top surface and intersecting therewith, above which at least one surface said diaphragm, in its position of rest, is freely suspended, and wherein, during operation of said emitter, flow regulation is at any instant carried out along the entire usable length of said flow-regulating labyrinth.

2. The flow-regulating element as claimed in claim 1, wherein the freely suspended portion of said diaphragm gradually varies from a maximum at the baffle closest to said inlet means, to a minimum at the baffle closest to said outlet means.

3. The flow-regulating element as claimed in claim 1, wherein said at least one surface is a surface sloping from said top surface downwards towards the center of said flow-regulating labyrinth.

4. The flow-regulating element as claimed in claim 1, further comprising a set of minor baffles, each minor baffle being positioned in the space between two of said toothlike baffles and having a downward sloping upper surface.

5. The flow-regulating element as claimed in claim 1, wherein the slope of the upper surface of said minor baffles is the same for all minor baffles.

6. The flow-regulating element as claimed in claim 1, further comprising a flow-attenuating labyrinth arranged upstream of said flow-regulating labyrinth.

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7. The flow-regulating element as claimed in claim 3, wherein the angle of slope of said at least one surface relative to said top surface gradually varies from a minimum at the toothlike baffle closest to said inlet means, to a maximum at the baffle closest to said outlet means.

8. The flow-regulating element as claimed in claim 3, wherein the angle of slope of said at least one surface relative to said top surface is the same for all of said toothlike baffles.

9. The flow-regulating element as claimed in claim 1, wherein said elastically deformable diaphragm is of a uniform thickness along its entire longitudinal extent.

10. The flow-regulating element as claimed in claim 1, wherein said elastically deformable diaphragm is of a gradually decreasing thickness along its entire longitudinal extent.

11. A line-pressure independent, regulated-flow, in-line drip irrigation emitter, comprising:

a substantially tubular emitter housing having a substantially cylindrical outer surface and being insertable into an irrigation line, with said outer surface tightly fitting the inner surface of said irrigation line;

an elongated body located inside, and integral with, said emitter housing;

a first set of meandering, interconnected recesses extending over a portion of said outer cylindrical surface and defining, in conjunction with said inner surface of said irrigation line, a flow-attenuating labyrinth, a first end of said flow-attenuating labyrinth communicating with said irrigation line, the second end thereof communicating via an aperture with a first end of a second set of meandering, interconnected recesses provided in said body and defining, in conjunction with an elastically deformable diaphragm, a flow-regulating labyrinth, the second end of which labyrinth communicates through a duct with the free atmosphere via at least one peripheral channel in said cylindrical body and via at least one hole in said irrigation line, said recesses in said flow-regulating labyrinth being defined by toothlike baffles projecting in a staggered arrangement from two opposite walls of said labyrinth, which toothlike baffles have a common top surface defining a position

Express Label No.
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of rest of said elastically deformable diaphragm, each of said baffles ending in a relatively narrow edge;

wherein said edge extends from the bottom of said recesses to a point at a height lower than the height of said top surface, at least one surface extending from each of said points towards said top surface and intersecting therewith, above which at least one surface said diaphragm, in its position of rest, is freely suspended and wherein, during operation of said emitter, flow regulation is at any instant carried out along the entire usable length of said flow-regulating labyrinth.

12. The drip irrigation emitter as claimed in claim 11, wherein the freely suspended portion of said diaphragm gradually varies from a maximum at the baffle closest to said aperture connecting said flow-regulating labyrinth with said flow-attenuating labyrinth, to a minimum at the baffle closest to said duct.

13. The drip irrigation emitter as claimed in claim 11, wherein said at least one surface is a surface sloping from said top surface downwards towards the center of said flow-regulating labyrinth.

14. The drip irrigation emitter as claimed in claim 11, further comprising a set of minor baffles, each minor baffle being positioned in the space between two of said toothlike baffles and having a downward sloping upper surface.

15. The drip irrigation emitter as claimed in claim 11, wherein the slope of the upper surface of said minor baffles is the same for all minor baffles.

16. The drip irrigation emitter as claimed in claim 11, wherein the angle of slope of said at least one surface relative to said top surface gradually varies from a minimum at the toothlike baffle closest to said inlet means, to a maximum at the baffle closest to said outlet means.

17. A boat-type, regulated-flow, in-line drip irrigation emitter, comprising:

an elongated body attachable to the inside wall of an irrigation water supply line;

a first set of meandering, interconnected recesses extending over a portion of the outside surface of said body and defining, in conjunction with said inside wall, a flow-attenuating labyrinth, a first end of said flow-attenuating labyrinth communicating with said supply line and a second end thereof communicating via an

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EV342539854US

aperture with a first end of a second set of meandering, interconnected recesses located in said body and defining, in conjunction with an elastically deformable diaphragm, a flow-regulating labyrinth, the second end of which labyrinth communicates with the free atmosphere via a pool-like depression in said body and via at least one hole in said line, said recesses in said flow-regulating labyrinth being defined by toothlike baffles projecting in a staggered arrangement from two opposite walls of said labyrinth, which toothlike baffles have a common top surface defining a position of rest of said elastically deformable diaphragm, each of said baffles tapering down towards a relatively narrow edge;

wherein said edge extends from the bottom of said recesses to a point at a height lower than the height of said top surface, at least one surface extending from each of said points towards said top surface and intersecting therewith, above which at least one surface said diaphragm, in its position of rest, is freely suspended and wherein, during operation of said emitter, flow regulation is at any instant carried out along the entire usable length of said flow-regulating labyrinth.

18. The emitter as claimed in claim 17, wherein the freely suspended portion of said diaphragm gradually varies from a maximum at the baffle closest to said aperture connecting said flow-regulating labyrinth with said flow-attenuating labyrinth, to a minimum at the baffle closest to said duct.

19. The emitter as claimed in claim 17, wherein said at least one surface is a substantially planar surface sloping from said top surface downwards towards the center of said flow-regulating labyrinth.

20. The emitter as claimed in claim 17, further comprising a set of minor baffles, each minor baffle being positioned in the space between two of said toothlike baffles and having a downward sloping upper surface.

21. The emitter as claimed in claim 17, wherein the slope of the upper surface of said minor baffles is the same for all minor baffles.

22. The emitter as claimed in claim 17, wherein the angle of slope of said at least one surface relative to said top surface gradually varies from a minimum at the toothlike baffle closest to said inlet means, to a maximum at the baffle closest to said outlet means.

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23. A button-type, regulated-flow drip irrigation emitter, comprising:

a two-part housing, a first part of which is provided with inlet means connectable to an irrigation line, and a second part of which is provided with outlet means, said first and second parts being joinable by joining means;

a disk-shaped, elastically deformable diaphragm disposed between said first and said second housing parts, and having a substantially central opening communicating in the mounted position of said diaphragm with said inlet means;

a first set of meandering, interconnected recesses extending over a portion of an inside surface of said second housing part and defining, in conjunction with said diaphragm, a flow-attenuating labyrinth, a first end of which communicates via said opening in said diaphragm with said irrigation line, the second end thereof being connected to the first end of a second set of meandering, interconnected recesses provided in said surface of said second housing part and defining, in conjunction with said diaphragm, a flow-regulating labyrinth, the second end of which communicates with said outlet means,

said recesses in said flow-regulating labyrinth being defined by toothlike baffles projecting in a staggered arrangement from two opposite walls of said labyrinth, which toothlike baffles have a common top surface defining a position of rest of said elastically deformable diaphragm, each of said baffles ending in a relatively narrow edge;

wherein said edge extends from the bottom of said recesses to a point at a height lower than the height of said top surface, at least one surface extending from each of said points towards said top surface and intersecting therewith, above which at least one surface said diaphragm, in its position of rest, is freely suspended and wherein, during operation of said emitter, flow regulation is at any instant carried out along the entire usable length of said flow-regulating labyrinth.

24. The drip irrigation emitter as claimed in claim 23, wherein said flow-attenuating labyrinth and said flow-regulating labyrinth are arcuate.

25. The drip irrigation emitter as claimed in claim 23, wherein said flow-attenuating labyrinth and said flow-regulating labyrinth are substantially co-planar.

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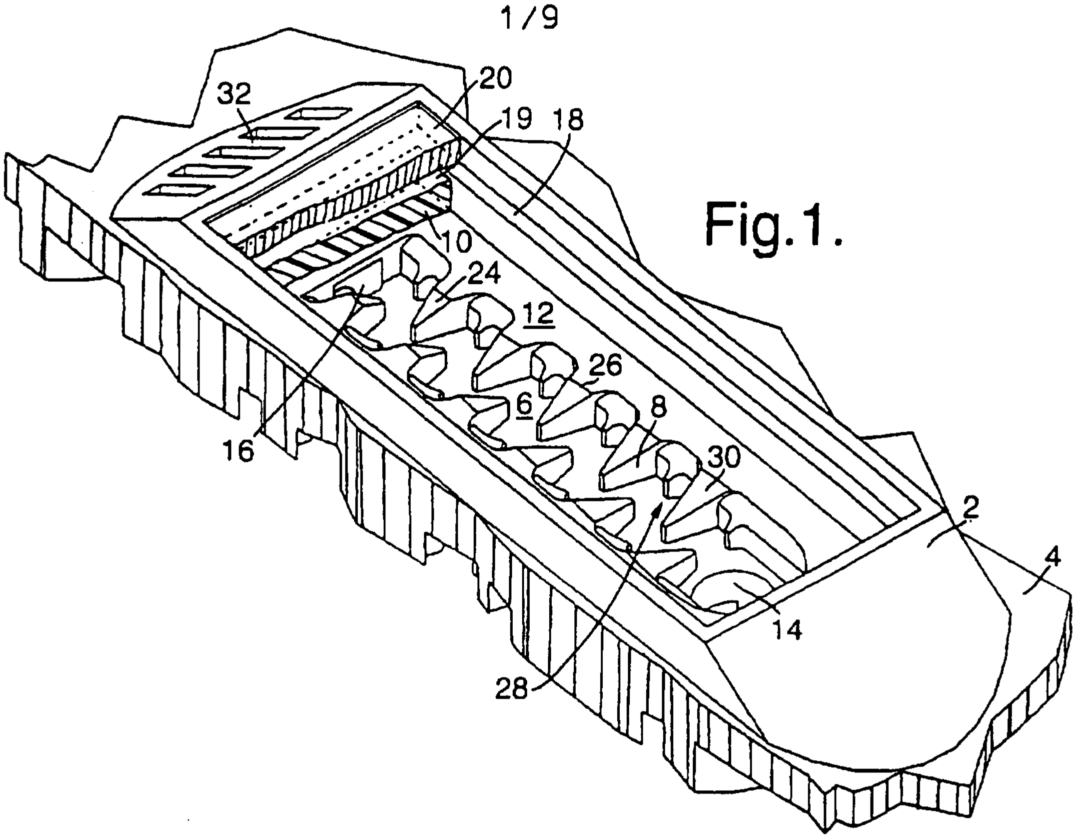


Fig.1.

Fig.2.

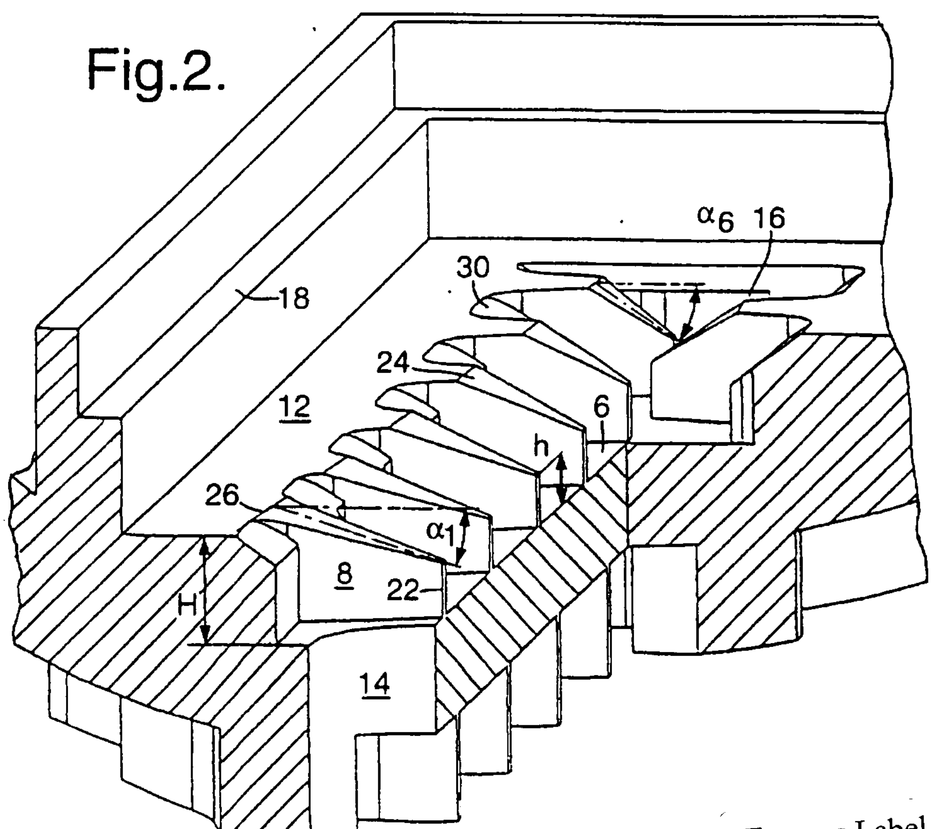


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Fig.3.

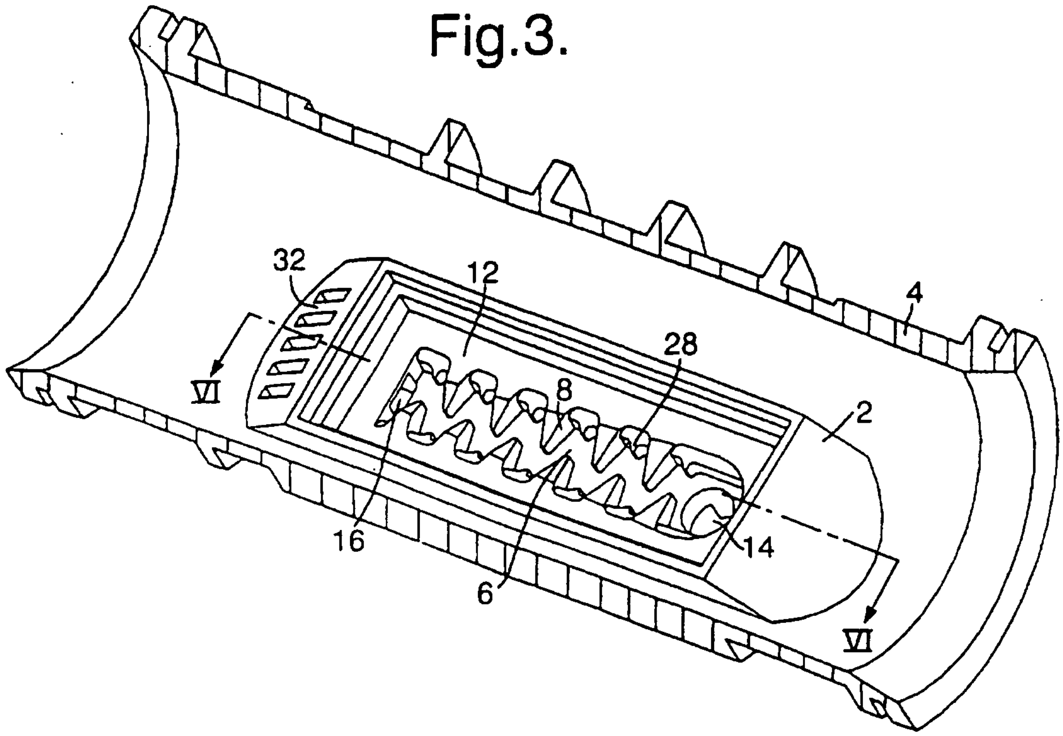


Fig.4.

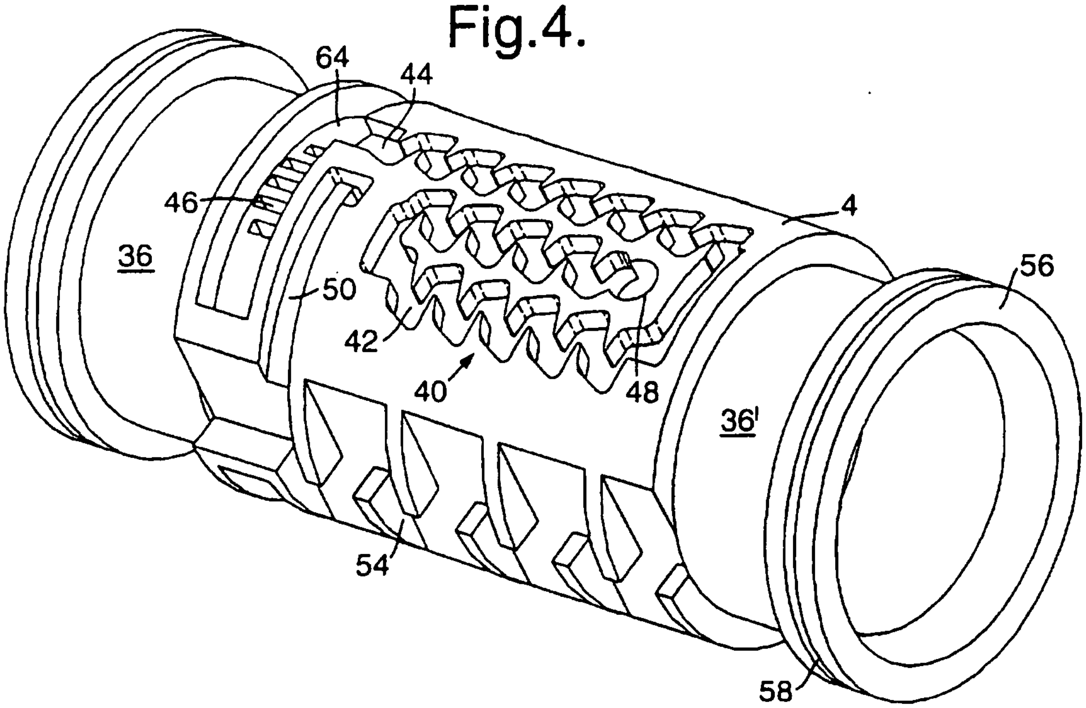


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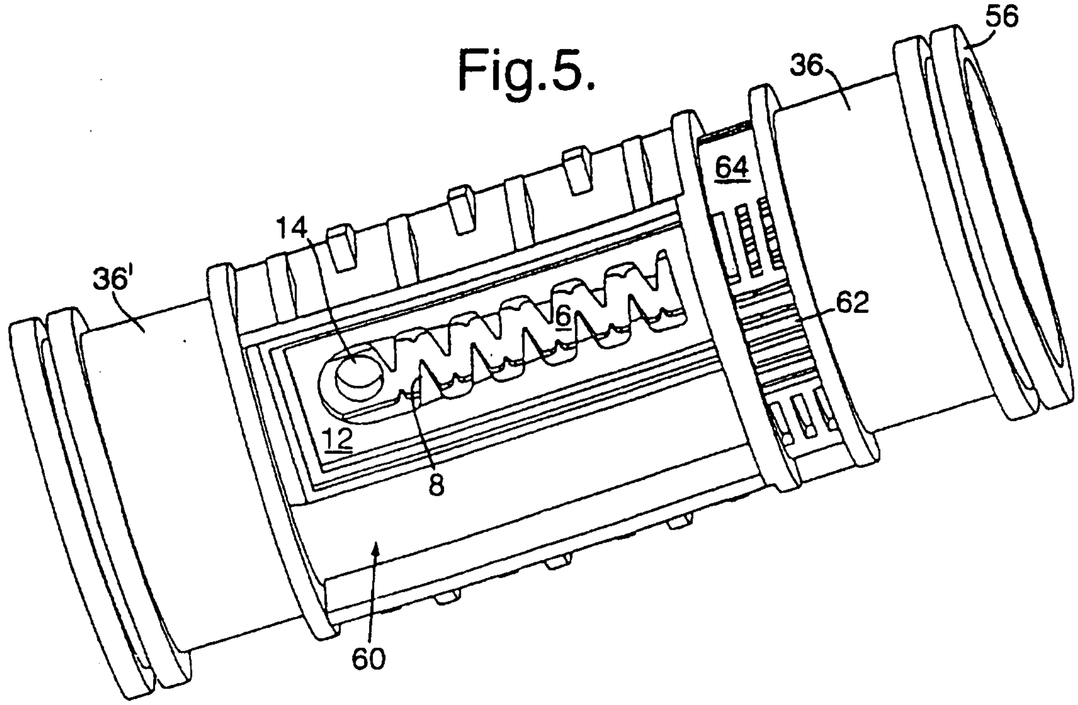
Fig.5.

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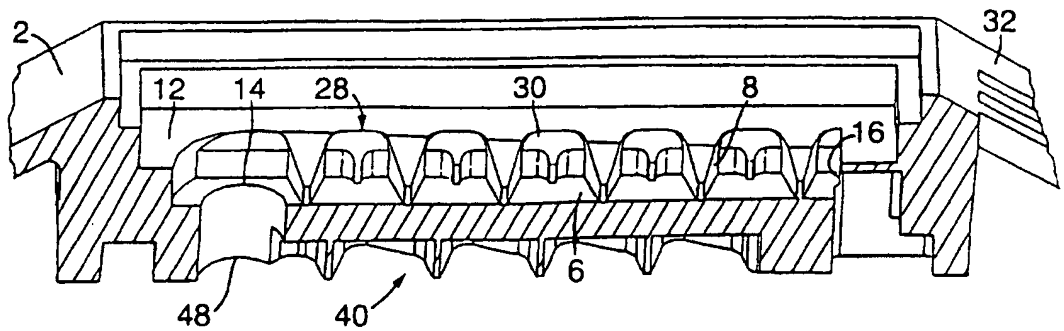


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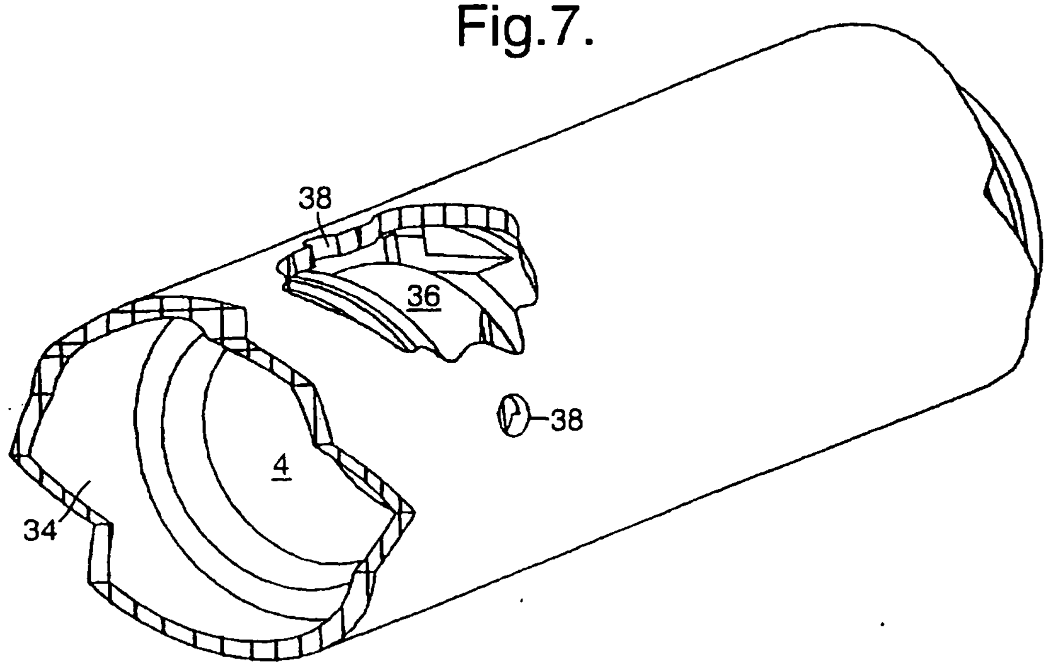


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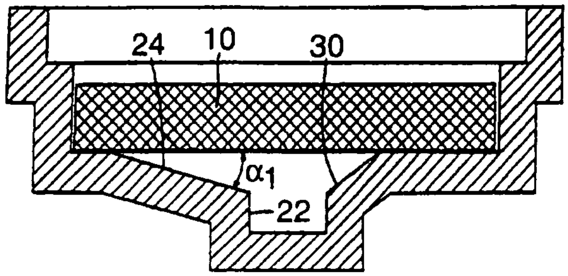


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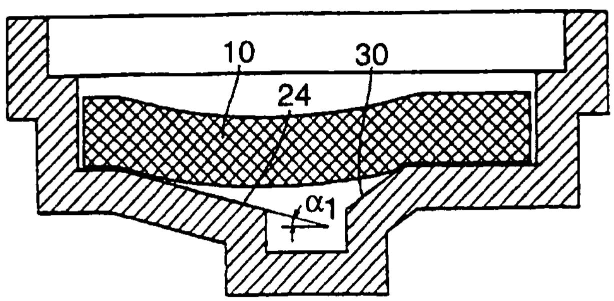


Fig.10.

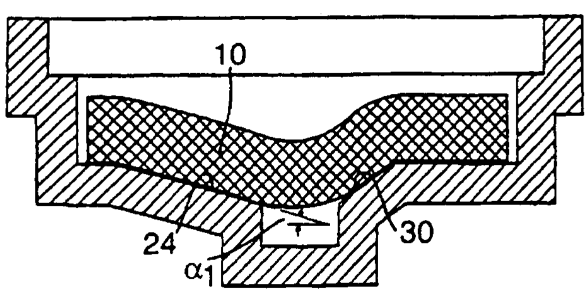


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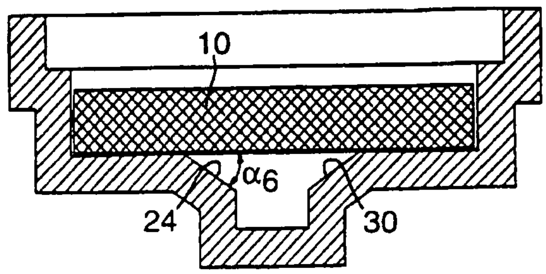
Fig. 11.

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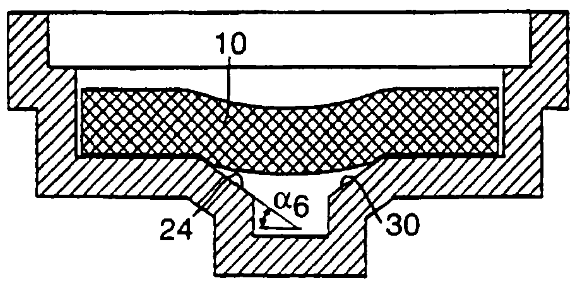


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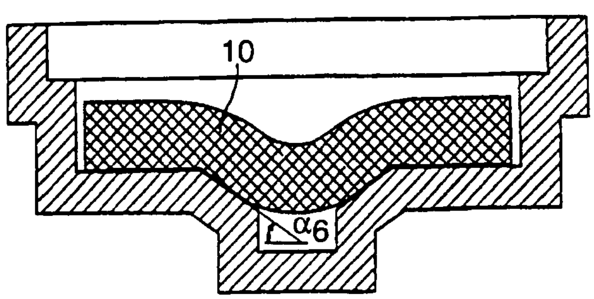


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Fig. 14.

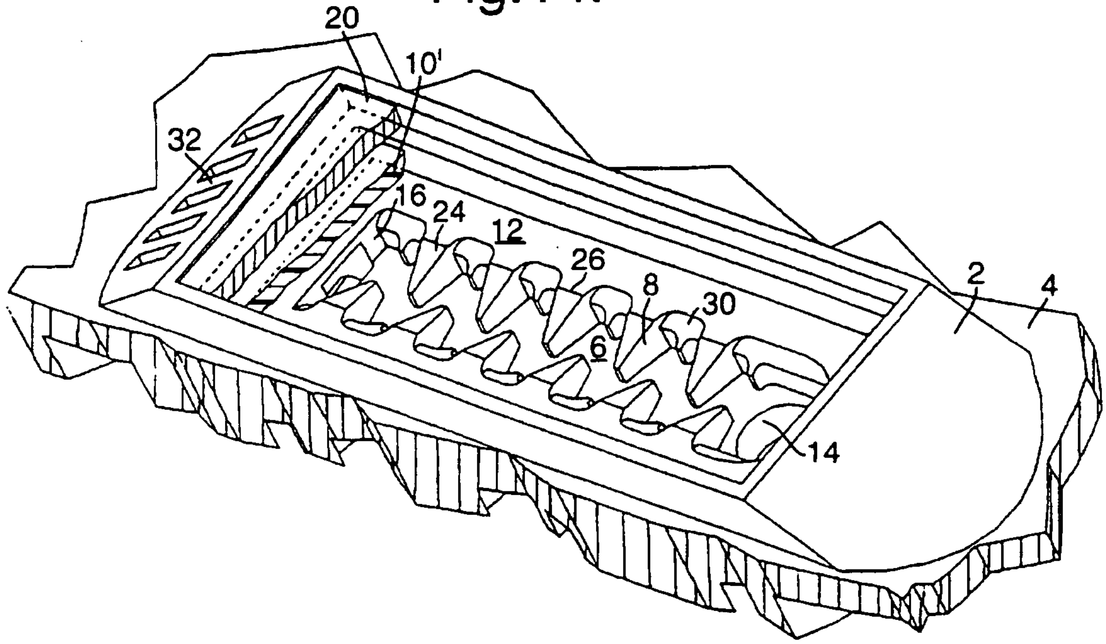


Fig. 15.

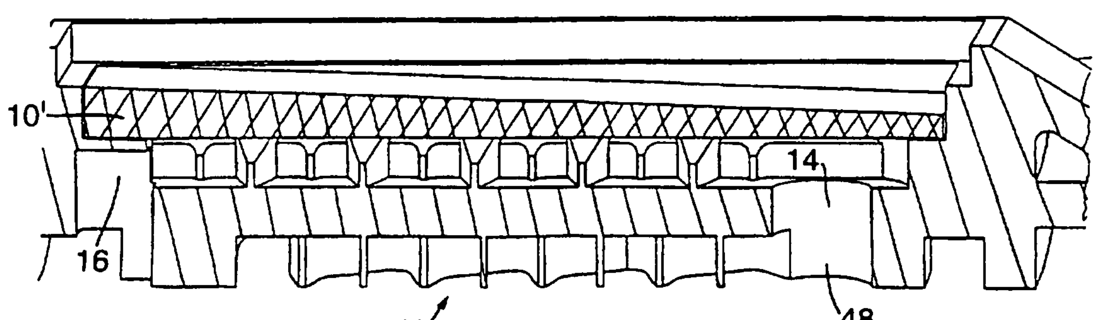


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Fig.16.

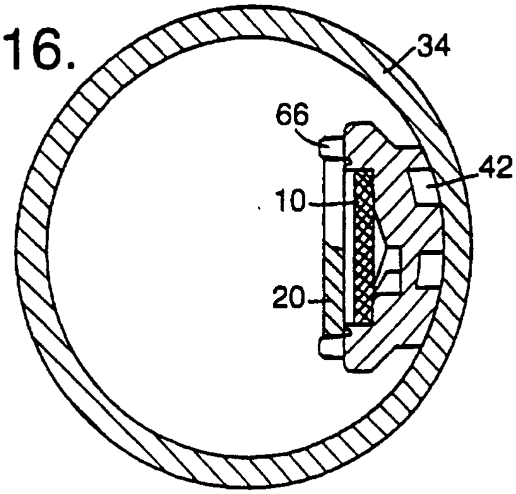


Fig.17.

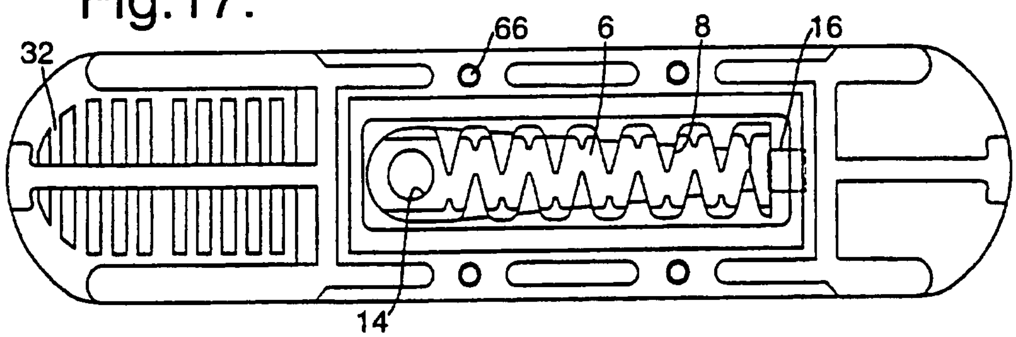


Fig.18.

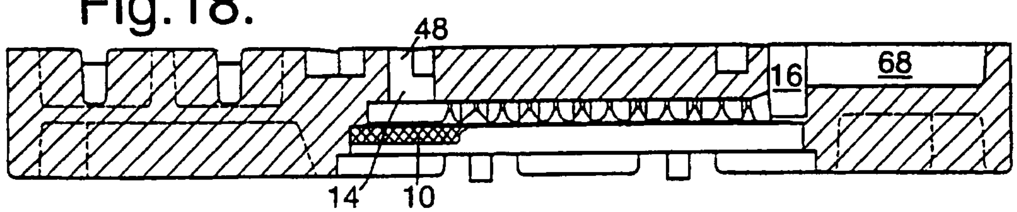


Fig.19.

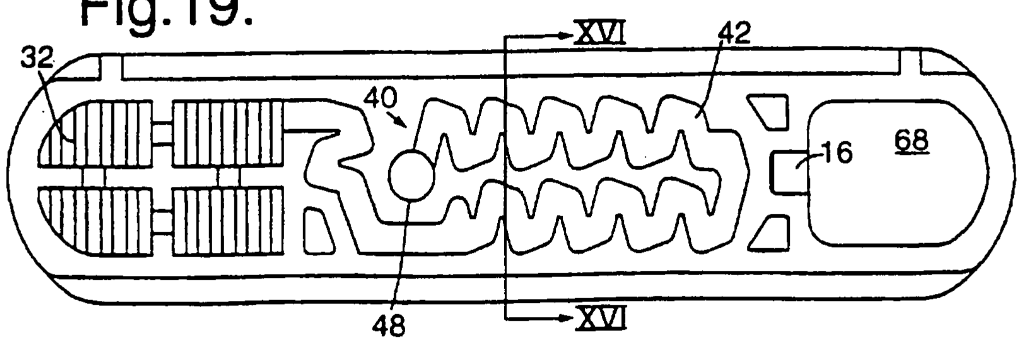


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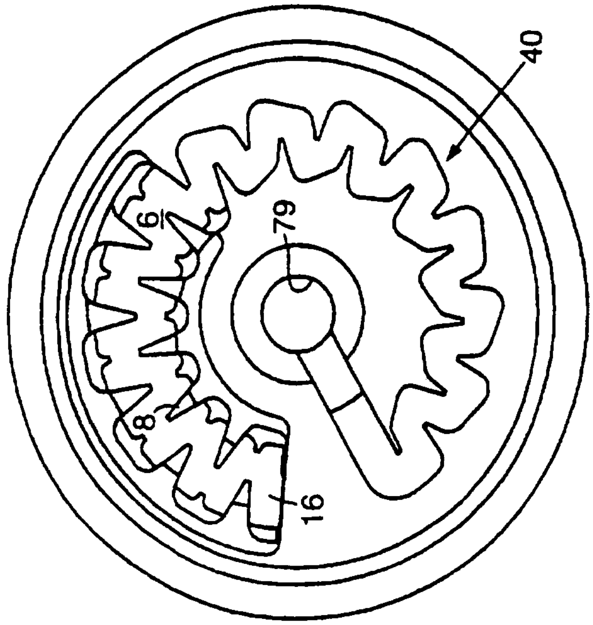
Fig.21.

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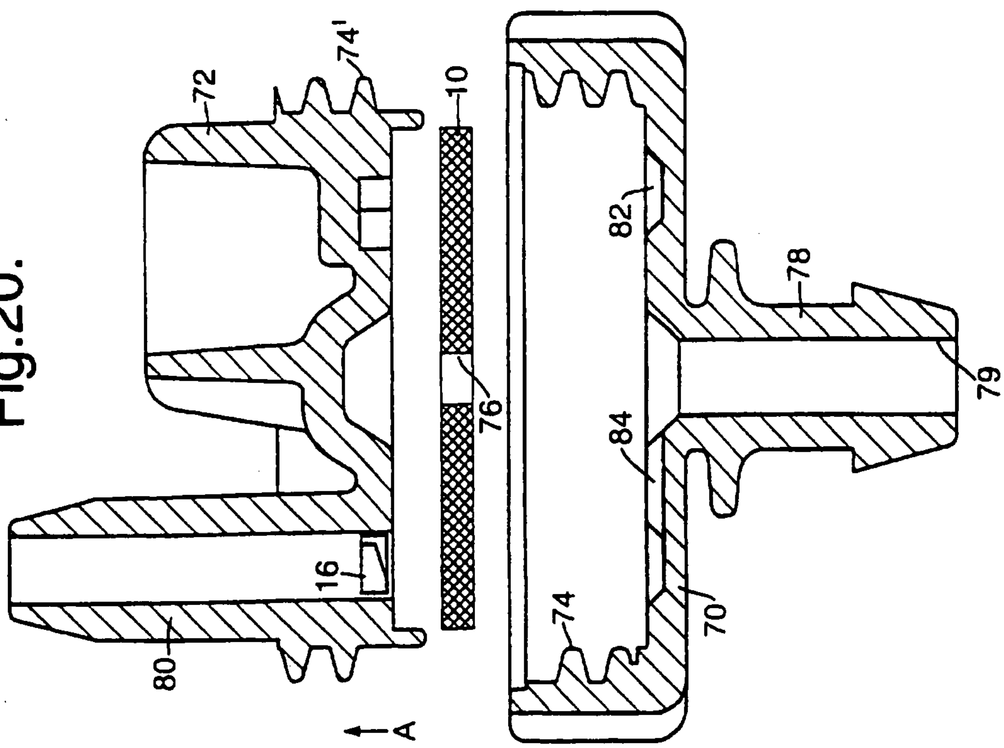


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# INTERNATIONAL SEARCH REPORT

International Application No
PCT/IL 97/00298

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 6 A01G25/02

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A01G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | EP 0 636 309 A (COHEN) 1 February 1995<br>see column 3, line 35 - column 7, line 57; figures 1-18<br>& US 5 400 973 A<br>cited in the application<br>----- | 1,11,17, 23 |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 4 December 1997 | 17/12/1997 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Herygers, J |

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